Agent Coordination by Trade-off between Locally Diffusion Effects and Socially Structural Influences

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ABSTRACT

There were always two separated methods to make agent coordination: individual-local balance perspective and individual-society balance perspective. The first method only considered the balance between individual agents and their local neighbors; the second method only considered the balance between individual agents and the whole multi-agent society. However, in reality, the agents will be diffused by their local neighbors as well as influenced by their social contexts simultaneously; therefore, it is necessary to deal with the social performance as well as local performance. To address such problem this paper presents an agent coordination method in an integrative model where we combine the two perspectives together and make trade-off between them. With our presented model, the individual, local and social concerns can be balanced well in a unified and flexible manner. Moreover, the experimental results show that there are often situations in which the two coordination perspectives aren't conflictive but often bring out the better in each other.

Categories and Subject Descriptors

I.2.11 [**Distributed Artificial Intelligence**]: Multiagent Systems.

General Terms

Theory, Design, Performance, Experimentation.

Keywords

Multiagent System, Coordination, Local Diffusion, Social Influence, Unification Trend.

1. INTRODUCTION

A strategy is the action that agent adopts to behave in the multi-agent society; it is necessary to make coordination among agent strategies [1]. In multi-agents, there is an interesting phenomenon which can be called *unification trend*: when many agents operate concurrently in the system, they will incline to adopt an average strategy which can make the system be more unified [3][4][5][6].

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An agent doesn't require being aware of every agents in the society, it may only know its local neighbors and the counterparts within its social contexts. Therefore, the social strategy of an agent will be determined by: 1). *Locally diffusion effects*: the agent strategies will diffuse to each other in the local area, and agents will incline to the average strategy within neighboring region [5][6][7][8]; 2). *Social influence*: agents will also be influenced by its social contexts especially the socially structural counterparts, therefore, agents will also incline to the consensus-strategy within the social contexts [9].

Until now almost all related work on multi-agent coordination can be mainly categorized as falling into one of two general classes: individual-local balance perspective; individual-society balance perspective. In the first class, they only consider the balance between individual and local concerns [5][6][7][8], which may not get the globally social performance if we only consider the balance between individual and local concerns. Whereas, in the second class, they only consider the balance between individual and social concerns [9], which may get the social performance but ignore the local effects. Moreover, the control on the whole agent society is sometimes difficult to achieve. Therefore, in this paper we provide an integrative model for agent coordination by trade-off between locally diffusion effects and socially structural influences. With our model, the individual, local and social concerns can be balanced well in a unified and flexible manner. Moreover, the experimental results show that the two perspectives aren't conflictive but often bring out the better in each other.

2. LOCALLY DIFFUSION EFFECTS

In [5], Reynolds initiated a research to explore the simulation for a flock of birds who coordinate with each other by a local control strategy to adopt a common average heading. Jadbabaie,Vicsek, and Lin presented that the agent's strategy is often updated using a local rule based on the average of its own strategy plus the strategies of its "neighbors" [6-8]. In the local diffusion effects, agents adjust their social strategies over time by myopically imitating the average strategy within their own neighborhoods.

Now, we make balance between the agent's initial strategy and the average one of neighbors. Let $s_i(t)$ denote the strategy of agent a_i at time t, L_i be the local interaction region of agent a_i, when we make balance between individual agent and the locally diffusion effects of neighboring agents, the new strategy of agent a_i will be:

$$s_i^L(t+1) = \alpha s_i(t) + \beta \frac{1}{|L_i|}\sum_{j\in L_i} s_j(t) \tag{2.1}$$

Where α is the inertia factor of the strategy of agent a_i, β is the influence factor of L_i to a_i, $\alpha+\beta=1$.

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3. SOCIALLY STRUCTURAL INFLUENCE

An agent is in some social contexts or organizations [2], the agent strategy is influenced not only by the local neighbors but also the counterparts within the social contexts.

Now, let agent a_i be in a social organization structure, the social strategy of a_i will be influenced by all agents in its contexts. So a_i will go toward to the average of all socially structural influences of its contexts regarding their respective influence strengths.

$$s_i^S(t+1) = \sum_{j\in\sum\Theta_i} \left(s_j \frac{I_{j\to i}}{\sum_{x\in\sum\Theta_i} I_{x\to i}}\right) \tag{3.1}$$

Where s_j denotes the social strategy of agent a_j, $s_i^S(t+1)$ denotes the new social strategy of a_i if it fully obeys the social influence, $\sum\Theta_i$ denotes the social contexts of a_i, $I_{j\to i}$ denotes the social influence strength of a_j to a_i.

4. BALANCE BETWEEN TWO PERSPECTIVES

4.1 Trade-off

To make trade-off between locally diffusion effects and socially structural influences, the strategy of agent a_i can be changed as:

$$\begin{aligned} s_i(t+1) &= \lambda_L s_i^L(t+1) + \lambda_S s_i^S(t+1) \\ &= \lambda_L\left(\alpha s_i(t) + \beta\frac{1}{|L_i|}\sum_{j\in L_i} s_j(t)\right) + \lambda_S \sum_{j\in\sum\mho_{a_i}}\left(s_j \frac{CI_{j\to i}}{\sum_{x\in\sum\mho_{a_i}} CI_{x\to i}}\right) \end{aligned} \tag{4.1}$$

The different concern tendencies can be realized by the variations of combination of the four parameters ($\alpha,\beta,\lambda_L,\lambda_S$), which determine the relative importance of the three concerns:

- $\alpha+\beta=1$: determine the trade-off between individual concern and local concern in locally diffusion effects. If $\alpha>\beta$, the agent will incline to its own strategy more than the locally average strategy; if $\alpha<\beta$, the agent will incline to the locally average strategy more than its own strategy; if $\alpha=\beta$, the agent will place equal concern between its own strategy and the locally average strategy in the diffusion effects.
- $\lambda_L+\lambda_S=1$: determine the trade-off between locally diffusion effects (include the individual concern and local concern in locally diffusion) and socially structural influence. If $\lambda_L>\lambda_S$, the agent will incline to the locally diffusion effects more than the socially structural influence; if $\lambda_L<\lambda_S$, the agent will incline to the socially structural influence more than the locally diffusion effects; if $\lambda_L=\lambda_S$, the agent will place equal concern between the locally diffusion effects and the socially structural influence.

4.2 Performance Index

For the unification trend said in Section 1, each agent will try to be gregarious to its local neighbors or socially contexts. Therefore, we can define the following two performance indexes.

4.2.1. Local Gregariousness of Individual Agents

The average strategy value within the local region of agent a_i is:

$$\overline{s_{L(i)}} = \frac{1}{1+|L_i|}\left(s_i + \sum_{j\in L_i} s_j\right) \tag{4.2}$$

The local gregariousness of agent a_i in its local region is:

$$\sigma_{L(i)} = 1 - \frac{|s_i - \overline{s_{L(i)}}|}{\overline{s_{L(i)}}} \tag{4.3}$$

Therefore, the average local gregariousness of all individual agents in the agent set A can be defined as:

$$\overline{\sigma_A} = \frac{1}{|A|}\sum_{i\in A}\sigma_{L(i)} = \frac{1}{|A|}\sum_{i\in A}\left(1 - \frac{|s_i - \overline{s_{L(i)}}|}{\overline{s_{L(i)}}}\right) \tag{4.4}$$

Higher values of $\overline{\sigma_A}$ indicate that better average local gregariousness performance of all agents can be gotten.

4.2.2 .Social Gregariousness of Individual Agents

The average strategy value of the agent society A is:

$$\overline{s_A} = \frac{1}{|A|}\sum_{i\in A} s_i \tag{4.5}$$

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Table 2. Test results for varying agent distributions

Local-Society		Individual-Neighbor		Performance Indexes for Varying Agent Distributions					
λ_L	λ_S	α	β	Cluster like distribution		Even distribution		Random distribution	
				$\overline{\sigma_A}$	$\overline{\omega_A}$	$\overline{\sigma_A}$	$\overline{\omega_A}$	$\overline{\sigma_A}$	$\overline{\omega_A}$
1	0	1	0	0.4889	0.4168	0.5757	0.4879	0.5589	0.6779
		0.75	0.25	0.6384	0.5542	0.7381	0.5929	0.6865	0.7249
		0.5	0.5	0.7735	0.6792	0.8524	0.6667	0.8022	0.7934
		0.25	0.75	0.8861	0.7742	0.8947	0.7049	0.8995	0.8821
		0	1	0.9045	0.7890	0.8499	0.6929	0.9172	0.9892
0.75	0.25	1	0	0.6295	0.5652	0.7084	0.6171	0.6763	0.7593
		0.75	0.25	0.7363	0.6675	0.8173	0.6955	0.7689	0.7943
		0.5	0.5	0.8343	0.7606	0.8976	0.7508	0.8536	0.8455
		0.25	0.75	0.9167	0.8313	0.9287	0.7792	0.9254	0.9118
		0	1	0.9299	0.8423	0.8973	0.7703	0.9384	0.9919
0.5	0.5	1	0	0.7590	0.7128	0.8139	0.7459	0.7875	0.8405
		0.75	0.25	0.8279	0.7803	0.8829	0.7980	0.8479	0.8636
		0.5	0.5	0.8917	0.8417	0.9343	0.8346	0.9034	0.8975
		0.25	0.75	0.9455	0.8881	0.9545	0.8534	0.9507	0.9414
		0	1	0.9541	0.8954	0.9343	0.8475	0.9592	0.9946
		1	0	0.8837	0.8579	0.7099	0.8744	0.8951	0.9216
		0.75	0.25	0.9164	0.8926	0.9432	0.9002	0.9248	0.9328
		0.5	0.5	0.9473	0.9223	0.9680	0.9182	0.9522	0.9494
		0.25	0.75	0.9735	0.9446	0.9780	0.9274	0.9755	0.971

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